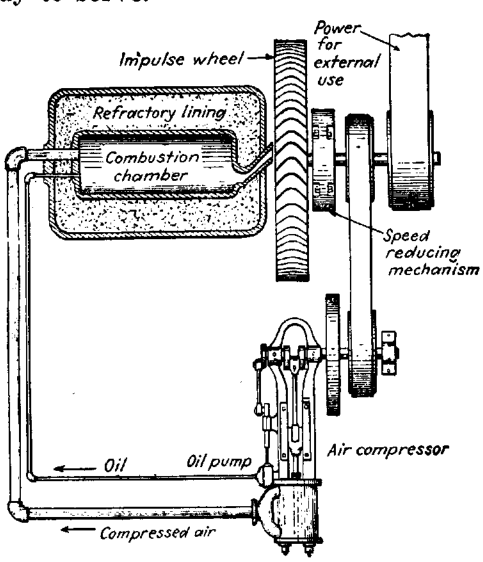
The Gas Turbine—A Different Prime Mover

By RAYMOND R. CURTIS, M.E. III

STIRRING increasing interest in industrial circles ever since it gained new publicity last June, the gas turbine, a prime generator of mechanical power, now awaits the war's end to offer this power to the nation. The gas turbine is not a new machine. As long ago as the last century, experimenters in Europe had developed a turbine which was turned by hot, expanding gases, but until very recent years any engine of this type was just too inefficient to deserve much recognition. However, research begun in 1936 and continued through these war-time years has led its promoters to announce with whole-hearted confidence that efficiencies equal to, or better than those of the diesel engines can be attained with the gas turbine. Thus, this compact power plant is ready to serve.



—Courtesy General Electric.

Diagrammatic Plan of Fundamental Gas Turbine

The principles which govern the operation of the gas turbine are quite simple. Air, this engine's first requirement, is taken in through a vent by a rotary air compressor of the axial-flow type, and is forced by the whirling compressor blades through a set of preheating tubes to the chamber. Here, an oil burner raises the temperature of the rushing air to almost destructive heights. Along with the products of combustion, this heated, and consequently, expanded air is turned into the turbine chamber. From the time it has left the compressor, the air has journeyed in a loop and now approaches the turbine in the same direction as it escaped from the compressor. As the turbine and compressor are mounted on the same shaft, the rotary motion of the turbine turns the compressor which continues the cycle. The turning shaft represents mechanical power. And so, briefly, these are the principles which control the gas turbine.

Now let us examine the engine in greater detail. To begin the gas turbine's cycle, power must be supplied from an outside source. (This is true in all energy converters.) In order to bring the system to an operating speed it is necessary to employ a starter moter very simple to the average automobile starter. The size of the turbine's starter would depend, however, on the inertia of the turbine and compressor, and on the friction resistance of their bearings. When the starter brings the compressor to a speed sufficient to supply an air flow of forty pounds per square inch, the burner is ignited, the starter declutched, and the cycle is begun.

A variety of fuels can be used in the gas turbine; oil, natural gas, producer gas, or (possibly in the future) even powdered coals can be burned in this engine's heating chamber. When cheap, bunker-C oil is used, it is sprayed from a nozzle-type burner into the rapidly moving stream of air. Its burning brings the air to nearly 1200 degrees Fahrenheit, a temperature which greatly increases the volume of the air, and would, if the air were confined, increase the pressure also. But, the heated air and also the gaseous product of fuel combustion are allowed to expand into the turbine chamber avoiding dangerous high pressures in the heating chamber, yet using the power of gas expansion to drive the turbine.

With the turbine running at operating speed it would seem that this engine's job were done. But, not so in the gas turbine. Even the exhaust gases are useful, for after they have driven through the turbine blades, they emerge, still hot, to pass around the tubes which lead the cold air from the compressor. In this manner the exhaust gases are used to preheat the air going to the burner, allowing it to bring the air to the required temperature with less fuel expenditure.

With these apparently advantageous qualities the gas turbine may be expected to take a place along with the renowned prime movers, the steam engine, the steam turbine, the gasoline and diesel engine. One may wonder, however, why it has not done so already, for it has been said that the idea for the gas turbine is very old. Several items have been serious drawbacks until recent years.

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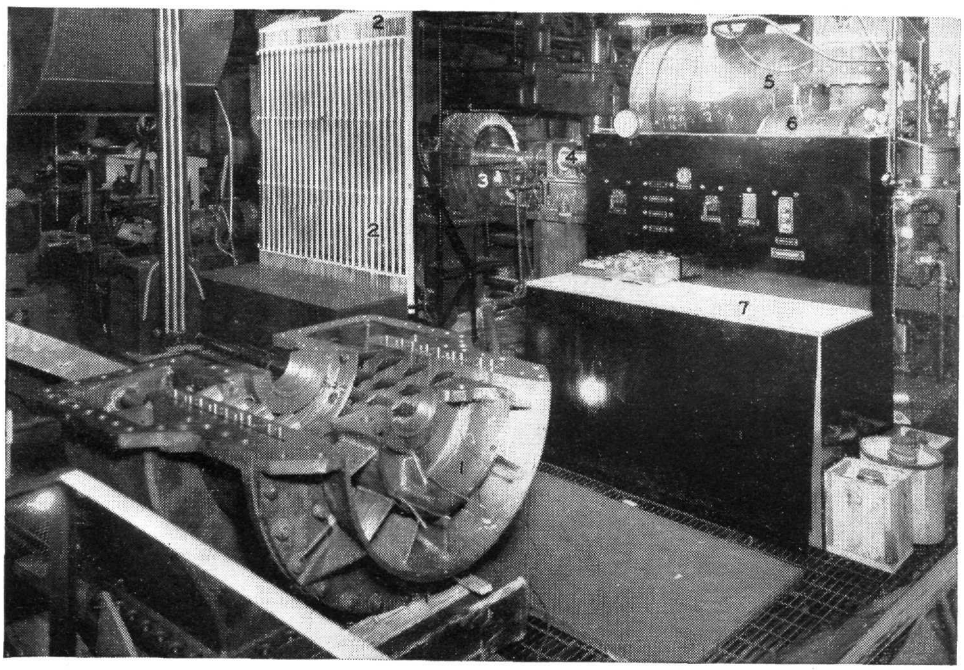
Low efficiency was the most objectionable hindrance to the turbine's advancement, for formerly it took nearly all the power that it could generate to drive its own air compressor. Another disadvantage was the inability of metals to withstand the heat and corrosion effects of the combustion gases. Lately, however, aeronautic research men have introduced new airfoil sections which have been as important to turbines and compressors as they have been to airplane contours and propellers. As a result the compressor can be driven with less than three-fourths the turbine's power. Also, the development of high-nickel alloy steels has made it possible to make turbines which can operate continuously in the highest temperature ever reached by the burning gases.



—*Courtesy General Electric.*

Gas-turbine Laboratory Now in Operation in the United States

The major problems, then, which have confronted gas turbine enthusiasts have been solved. With all losses accounted for it can be said that the gas turbine has an over-all efficiency of twenty to twenty-two percent. This performance rating is admittedly low when comparisons are made with the steam turbine with its efficiency of thirty percent, and the diesel which is rated at thirty-five. The gas turbine eliminates so many of the troubles inherent in the conventional engine, however, that its lower efficiency is counterbalanced to a large extent. Problems of cooling, hot-surface lubrication, vibration, and ignition virtually disappear. Therefore, with design simplified, the initial cost of the gas turbine is much lower than that of the conventional units, and, as the turbine can run on cheap-grade fuels, operating expenses are markedly cut. It has been reported that twenty-seven units are operating successfully in various war plants. Satisfactory performance definitely establishes the value of this machine.

Of course, much more research must be made before the gas turbine becomes a versatile engine, for up to the present time, units of less than 2000 horsepower have not been possible. It is interesting to note that a unit as small as a shoebox will provide enough power to drive an automobile, when a turbine this size can be built. The 2000 horse power machines will serve well for large installations such as in locomotives, ships, or the predicted large planes of the future. Also, turbines can be applied as stationary engines where there is a short water supply, or where space is limited, for the gas turbine can be completely contained in half the space required for an ordinary engine.

Wartime secrecy has withheld the publication of more of the striking qualities of the gas turbine, but lately, turbines which can operate at temperatures of 1500 degrees Fahrenheit have been produced. This announcement brings further encouragement, for higher temperatures mean better efficiencies, and better efficiencies spell further advancement for this engine.

Practical prime movers are rare machines, and the development of a different one in this twentieth-century era is a supreme achievement. Coming months will reveal the breath-taking possibilities of the gas turbine.